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OPTIMIZATION OF PROCESS PARAMETERS IN TURNING OPERATION OF AUSTENITIC STAINLESS STEEL ROD USING TAGUCHI METHOD AND ANOVA

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ABSTRACT

This research paper is an outcome of investigation made on the parameters those affects on austenitic stainless steel work piece roughness in the turning operation as a part of that the parameters involved in the operation were analyzed and formulated as a Design of experiments to check out the influence of them in the turning operation. Mainly spindle speed, feed rate and depth of cut were taken as chief contributors in the development of proper work piece surface. And the emphasis is made on the roughness of the work piece as a part of that the objective of the work is done to minimize the roughness by optimizing the process parameters. The results of the experiments made by the Taguchi's method have taken into further investigation by the Analysis of Variance (ANOVA) method. Out of all parameters the feed rate was found as an important parameter that influences the surface roughness.

KEYWORDS: Austenitic Stainless Steel, Taguchi Method, ANOVA, Turning & Surface Roughness

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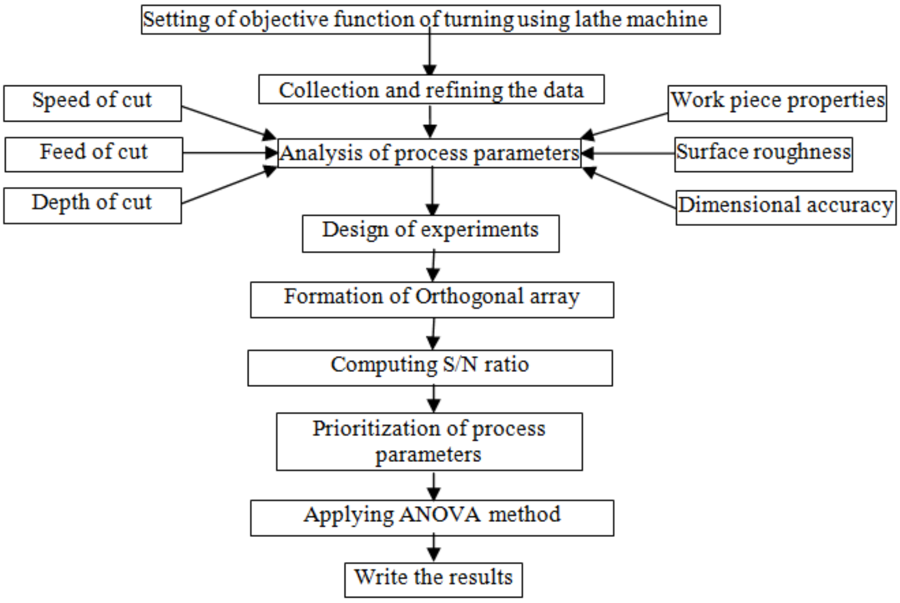
Original Article

INTRODUCTION

Any process on the machine should be performed optimally to get the best results. But archiving such outcome is a cumbersome task if parameters involved in that operation left idle without analysis. Taguchi and ANOVA were the chief methods in the arena of process parameter optimization. These methods will give the best results in terms of prioritization of emphasis on process parameters. Right from the formulation of the orthogonal array to refining the parameters data in association with the planned number of experiments such as nine or twenty seven. Then the signal to noise ratio (S/N) describes the ratio of desirable to undesirable output characteristics.[1,2,3] It in turn calculates the ratio of mean to standard deviation of the taken parameter values. Thus this ratio depicts the percentage of outcome quality. From this in further analysis emphasis can be made on the desired parameters. That means an outcome can be obtained using the Taguchi method and further refining can be done by the ANOVA method. That is analysis of variance.

Out of the above said processes cost is another concern. For any machining process or manufacturing system the cost should be minimized with a maximum output quality. In order to archive this design of experiments is performed as defined by Taguchi. It will minimize the total number of experiments to access the logical relationships among the various process parameters. Here in this research for the turning process of the austenitic

stainless steel the surface finish and dimensional accuracy are important factors. So to archive this speed, feed and depth of cut are considered as the process parameters[4,5,6]. The entire process of optimization is illustrated in the below flow chart.



Flow Chart

The above flow chat describes the sequential operations of the process that has been implemented towards the formation of an optimal parametric design at significantly low cost. It is further to be noted that the Taguchi's design of process parameters is an off-line quality control that is been utilised throughout the process/product development. And this is made possible by the concept of design of experiments. By make use of this concept the effect of the parameters involved in the process such as speed of spindle, depth of cut and feed rate were analyzed. And their influence on the work piece surface roughness and dimensional accuracy were determined. By taking the proper measures in terms of the process parameters good surface finish can be obtained.

Then the ANOVA is another method intended for finding the influence of a process parameter from results of design of experiments. Further this process can be used for interpretation of the data obtained by the experiments. ANOVA is the analysis of variance by its name, this can be made possible by the computation of variance of any given process parameters subject to the design of experiments by a number of statistical methods. And further the nature of the variance is attributed as measure of process parameter's efficacy. The entire concept revolves around the mean and variances by the statistical tests[7,8].

If any parameter's test results over a period of experiments does not alter then its of practical importance. But which is not a reality in all practical purposes. Hence, in ANOVA the differences among the various outcomes are emphasized.

The ratio between the two variances determines the experiments significance statistically. The ratio of the variances does not get altered either by adding or multiplying with a constant. Hence the ANOVA method is a more tangible, accurate and error free[9,10].

The machining (turning) of the austenitic stainless steel is very difficult because high nickel present in it. With the conventional methods the machining process does not give proper outcome and the cutting tool also suffers with built up

edge over it. Hence the cutting tool used in this process is coated carbide tools. And the aluminium, titanium nitride coating (AlTiN) is applied on the carbide turning tool. This coating will strengthen the turning tool against the high temperatures and built up formation. The following list describes the turning process parameters at various levels.

Table 1

Expt Code	Cutting parameter	Levels		
		1	2	3
A	Speeds (rpm)	380	710	1050
B	Feed f (mm/rev)	0.05	0.08	0.12
C	Depth of cut d (mm)	0.5	0.75	1.0

The work piece austenitic stainless steel is used to make the turning process to obtain the diameter of 25mm. The main objective of the task is to obtain the shaft to a diameter of 25mm from 30mm with an optimum surface finish. The work piece dimensions are length of 300mm, diameter 30mm. The work piece material composition is given below.

Table 2

Material Grade	Fe	C	Mn	Si	P	S	Cr	Ni	N
Austenitic stainless steel	65-71%	0.03%	2%	0.75%	0.045%	0.03%	18-20%	8-12%	0.10%

In order to access the surface roughness of the work piece, the roughness is plotted and quantified with sections of 10mm each as a total of 250mm and the remaining 50mm is inserted into the lathe machine.

The below table illustrates the mechanical properties of the austenitic stainless steel.

Table 3

S. No	Mechanical Property	Value
1	Hardness Brinell’s	123
2	Tensile strength Ultimate	50 MPa
3	Tensile strength Yield	215 MPa
4	Elongation	70%
5	Modulus of elasticity	197 GPa
6	Poisson’s ratio	0.29

EXPERIMENTAL INVESTIGATIONS

The prime objective of the research surface roughness is measured by the photographic investigation of the surface at various sections. And they are cross checked by the conventional methods for surface roughness. Viz., RMS method, CLA method. With the consideration of all these tests the most relevant and appropriate value has been evolved. And in addition to this the process parameters such as speed, feed and depth of cut all the values were recorded and tabulated as per the requirement of the Taguchi’s design of experiments. That is 27 values for each variable as shown below.

Table 4

Expt No	Control Factors			Parameters			Surface Roughness μmm	S/N ratio
	A	B	C	Speed	Feed	Depth of		
	s	f	d	rpm	mm/rev	cut mm		
1	1	1	1	380	0.05	0.5	2.08	12.4642
2	1	1	2	380	0.05	0.75	2.17	12.4642
3	1	1	3	380	0.05	1	1.72	12.4642
4	1	2	1	380	0.08	0.5	1.74	33.9794

Table 4: Contd.,

5	1	2	2	380	0.08	0.75	1.76	33.9794
6	1	2	3	380	0.08	1	1.78	33.9794
7	1	3	1	380	0.12	0.5	1.78	12.7300
8	1	3	2	380	0.12	0.75	2.18	12.7300
9	1	3	3	380	0.12	1	1.78	12.7300
10	2	1	1	710	0.05	0.5	1.82	14.5469
11	2	1	2	710	0.05	0.75	2.09	14.5469
12	2	1	3	710	0.05	1	2.18	14.5469
13	2	2	1	710	0.08	0.5	2.08	
14	2	2	2	710	0.08	0.75	1.87	
15	2	2	3	710	0.08	1	1.83	
16	2	3	1	710	0.12	0.5	1.94	
17	2	3	2	710	0.12	0.75	2.19	
18	2	3	3	710	0.12	1	2.49	
19	3	1	1	1050	0.05	0.5	1.87	
20	3	1	2	1050	0.05	0.75	1.73	
21	3	1	3	1050	0.05	1	1.78	
22	3	2	1	1050	0.08	0.5	1.82	
23	3	2	2	1050	0.08	0.75	2.09	
24	3	2	3	1050	0.08	1	2.18	
25	3	3	1	1050	0.12	0.5	2.08	
26	3	3	2	1050	0.12	0.75	2.17	
27	3	3	3	1050	0.12	1	1.72	

Response Table for Signal to Noise Ratios

Nominal is best (-10×Log10(s^2))

Table 5

Level	A	B	C
1	19.72	16.66	12.74
2	14.40	21.99	20.33
3	16.66	12.13	17.72
Delta	5.33	9.86	7.59
Rank	3	1	2

The above table depicts the S/N ratio for the surface roughness it is been prepared by the Minitab software.

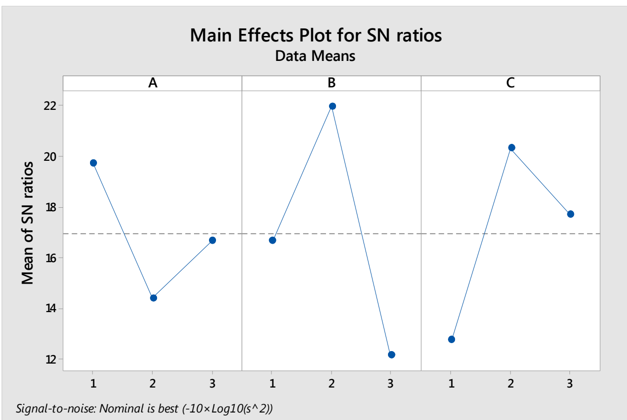


Figure 1

The order of preferences among the above listed process parameters has arrived to a conclusion that the first priority is to be made on feed of turning then the depth of cut and last speed of turning. Then the optimal surface finish can be obtained. However, this is the feasible solution and can be further quantified and correlated using the ANOVA method as follows.

ANOVA CALCULATIONS

One-way ANOVA: Surface roughness versus Experiment Method

Table 6

Null hypothesis	All means are equal
Alternative hypothesis	Not all means are equal
Significance level	α = 0.05

The ANOVA calculations were made based on the above conditions with a significance level of 0.05. The surface roughness is analyzed for its optimality using the following tests. They have given a significant outcome to in terms of error. Equal variances were assumed for the analysis.

Table 7: Factor Information

Factor	Levels	Values
Experiment	3	A, B, C

Table 8: Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Experiment	2	0.08402	0.04201	0.99	0.386
Error	24	1.01898	0.04246		
Total	26	1.10300			

From the above table it is evident that the significant error value is found in the surface roughness with the process parameters. The F value is near to unity and the P value is less than 0.5 so the turning process is in good condition. However, it can be further enhanced by prioritization of the process parameters.

Table 9: Model Summary

S	R-square	R-square(adj)	R-square(pred)
0.206052	7.62%	0.00%	0.00%

The above table shows the R-square values with both adjusted and predicted. It is in association with the previous verdict made towards the prioritization of emphasis to be made on the process parameters.

Table 10: Means

Experiment	N	Mean	Standard Deviation	95% Confidence Interval
A	9	1.9378	0.1904	(1.7960, 2.0795)
B	9	1.9056	0.1652	(1.7638, 2.0473)
C	9	2.0367	0.2526	(1.8949, 2.1784)

The above table shows the mean and standard deviation values of the surface roughness at the pre fixed boundary conditions to the process parameters. The confidence interval also can be seen above. It is a good sign to have a large differencebetween the mean and standard deviation values. In addition to it these values justifies that the process is proper

condition. As an overall the pooled standard deviation = 0.206052.

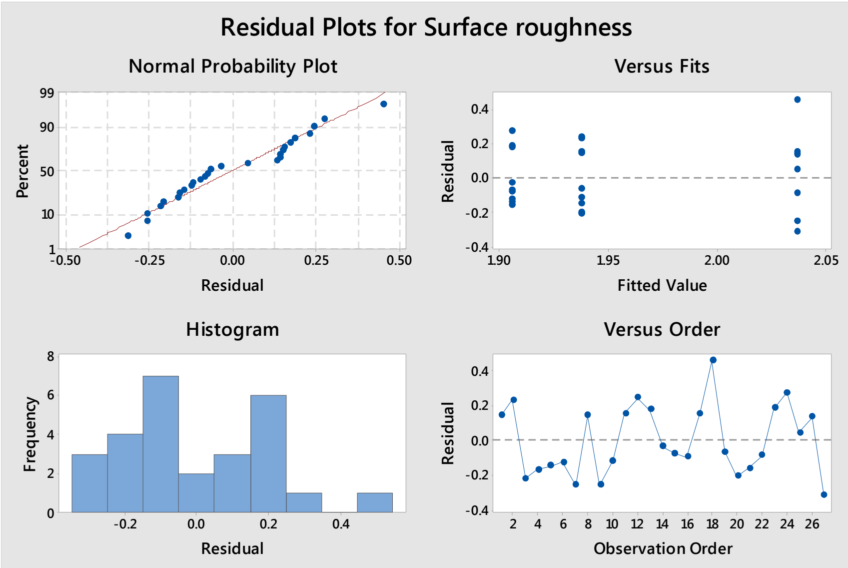


Figure 2: Residual Plots for Surface Roughness

The above figure shows the four different plots with interpreted data of surface roughness. In the first quarter the graph is about the fit, in between fitted value vs residual in it the values obtained were in the limits of ± 0.3 and one or two readings are above the limits. In the second quarter it's a normal probability plot drawn in between the residual to the percent. The graph shows the controlled operation. And the third one is in between frequency to the residual. Similarly the last drawn graph is an indication of interpretation between observation order to the residual.

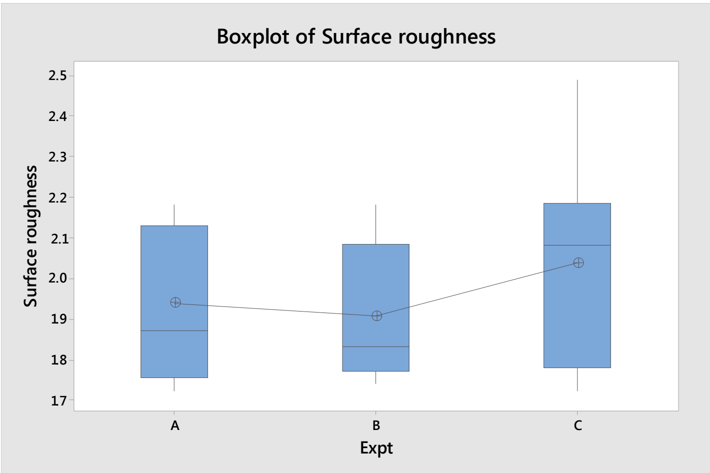


Figure 3: Box plot of Surface roughness

The above graph shows the experiment vs surface roughness. It represents a fall and rise in the roughness between the experiments. Yet the surface roughness can be reduced further.

CONCLUSIONS

The above research has made to conclude that the prioritization must be according to the results obtained. And the highest influence is made by the feed to get the proper surface roughness and then the depth of cut and speed is at the end. The optimum values obtained for these process parameters are feed =0.05mm/sec, depth of cut = 1.0mm, speed = 735rpm.

REFERENCES

1. *Chabbi, M. A. Yallese, M. Nouioua, I. Meddour, T. Mabrouki, François Girardin, Modeling and optimization of turning process parameters during the cutting of polymer (POM C) based on RSM, ANN, and DF methods, The International Journal of Advanced Manufacturing Technology, July 2017, Volume 91, Issue 5–8, pp 2267–2290*
2. *Ranganath MS, Vipin RS Mishra, Optimization of Process Parameters in Turning Operation of Aluminium (6061) with Cemented Carbide Inserts Using Taguchi Method and Anova, International Journal of Advance Research and Innovation, Volume 1, Issue 1 (2013) 13-21*
3. *Saini, P., & Choudhary, S. Analysis of Machining Parameters for the Optimization of Surface Roughness of Stainless Steel Aisi 202 In CNC Face Milling Process.*
4. *1aasheet Kumar, 2gaurav Chaudhary, 3manish Kalra, 4 S. Manoj Prabhakar, 5binit Kumar Jha, Optimization Of Turning Parameters By Using Taguchi Method For Optimum Surface Finish, International Journal Of Mechanical And Production Engineering, Issn: 2320-2092, Volume- 2, Issue- 5, May-2014*
5. *1Mahadev Naik, 2Ashish Gorule, 3Anil Ajgaonkar, 4Tejas Dudye, 5Tushar Chavan, Optimization of turning process parameters for AISI 410 Steel using Taguchi method, © 2016 IJEDR | Volume 4, Issue 2 | ISSN: 2321-9939*
6. *MdNasimuddina, Noor ZamanKhanb, Suha K. Shihabc, Arshad Noor Siddiqueeb, Optimization Of Turning Parameters Using Taguchi Method, International Journal of Scientific & Engineering Research Volume 8, Issue 7, July-2017 ISSN 2229-5518*
7. *Narendra Kumar Verma1, Ajeet Singh Sikarwar2, Optimizing Turning Process by Taguchi Method Under Various Machining Parameters, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 02 Issue: 06 | Sep-2015*
8. *S. Mohan Kumar, K. Kiran Kumar, Optimization Techniques in Turning Operation by using Taguchi Method, International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-6 Issue-6, August 2017*
9. *Sujit Kumar Jha, Parametric Optimization Of Turning Process Using Taguchi Method And Anova Analysis, International Journal of Advances in Engineering & Technology, June, 2016. ©IJAET ISSN: 22311963*
10. *Chu, N. H., & Nguyen, V. D. (2018). The Multi-Response Optimization of Machining Parameters in the Ultrasonic Assisted Deep-Hole Drilling Using Grey-Based Taguchi Method. Int. J. Mech. Prod. Eng. Res. Dev, 8, 417-426.*
11. *HariVasudevan, Shreya Kadwadkar, DharamRanka, Optimization Of Turning Process Parameters In The Machining Of An Accumulator (Mdn-250) Using Taghuchi's Design Of Experiment, International Journal of Mechanical And Production Engineering, ISSN: 2320-2092, Volume- 3, Issue-5, May-2015*